UNIT 1 — UEP VIII SEM Solution

Q1(A) A slab of insulating material 130 cm^2 in area and 1 cm thick is to be heated by dielectric heating. The power required is 380 W at 30 MHz. Material has a relative permittivity of 5 & P.F 0.05. Absolute permittivity = 8.854×10^{-12} F/m. Determine the necessary voltage.

Sol:- Given $A = 130\,cm^2 = 130 \times 10^{-4}\,m^2$

$t = 1\,cm = 0.01\,m$

$P = 380\,W$

$f = 30\,MHz = 30 \times 10^6\,Hz$

$\varepsilon_r = 5$

$PF = 0.05$

$\varepsilon_0 = 8.854 \times 10^{-12}\,F/m$

Capacitance $C = \frac{\varepsilon_0 \varepsilon_r A}{t} = \frac{8.854 \times 10^{-12} \times 5 \times 130 \times 10^{-4}}{0.01}$

$= 57.55 \times 10^{-12}\,F$

$P = 2\pi f C V^2 \cos\phi$

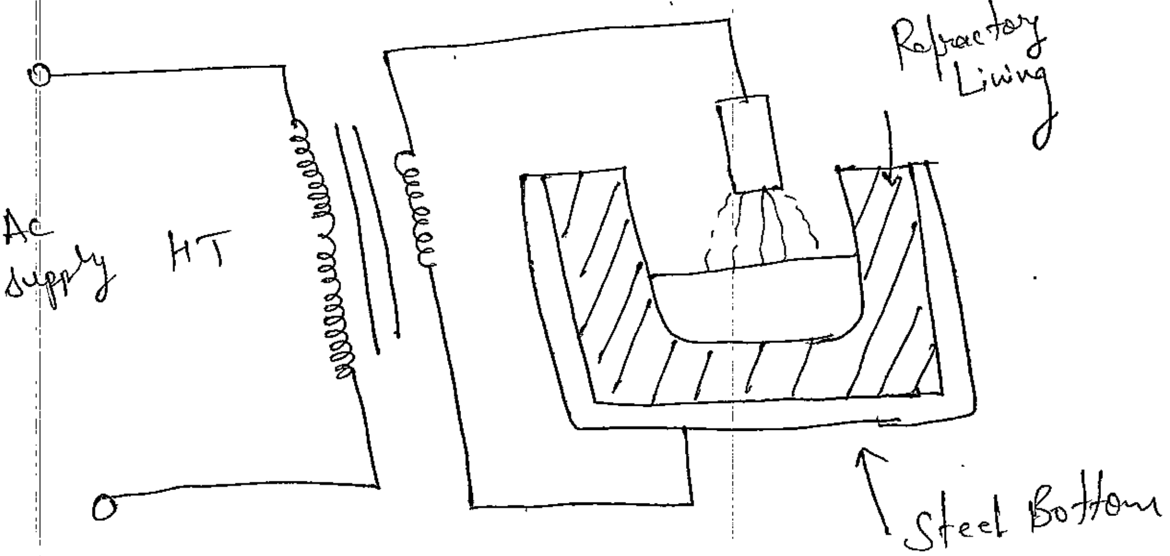
$380 = 2\pi \times 30 \times 10^6 \times 57.55 \times 10^{-12}\, V^2 \times 0.05$

$V^2 = \frac{380}{2\pi \times 30 \times 10^6 \times 57.55 \times 10^{-12} \times 0.05} = 700595$

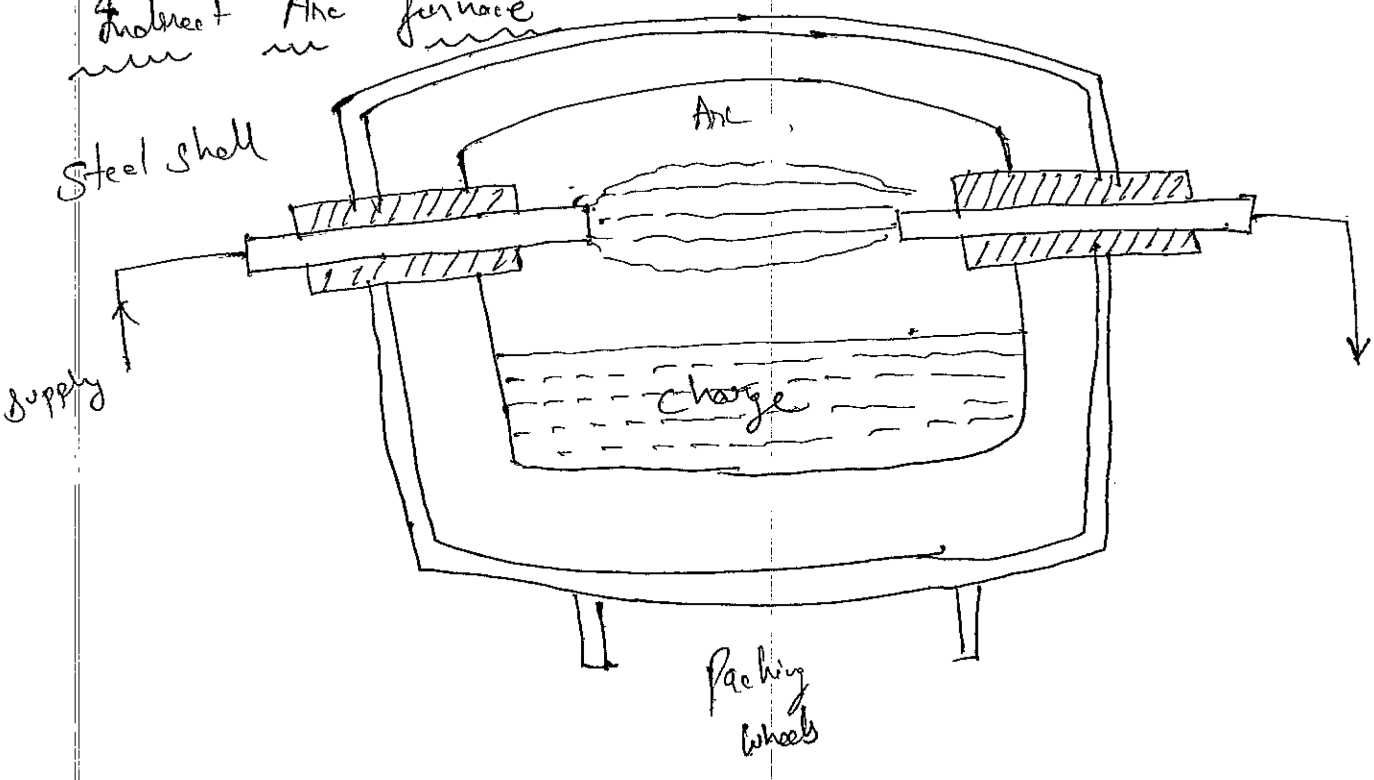
$\therefore V = \sqrt{700595} = 837$ Volts Ans

(B) Explain with neat sketches the principle of working & temperature control methods of Direct & Indirect arc furnaces.

Direct Arc Furnace



Indirect Arc furnace



In direct arc furnace arc is formed between the two electrodes and the charge in such a way that electric current passes through the body of the charge.

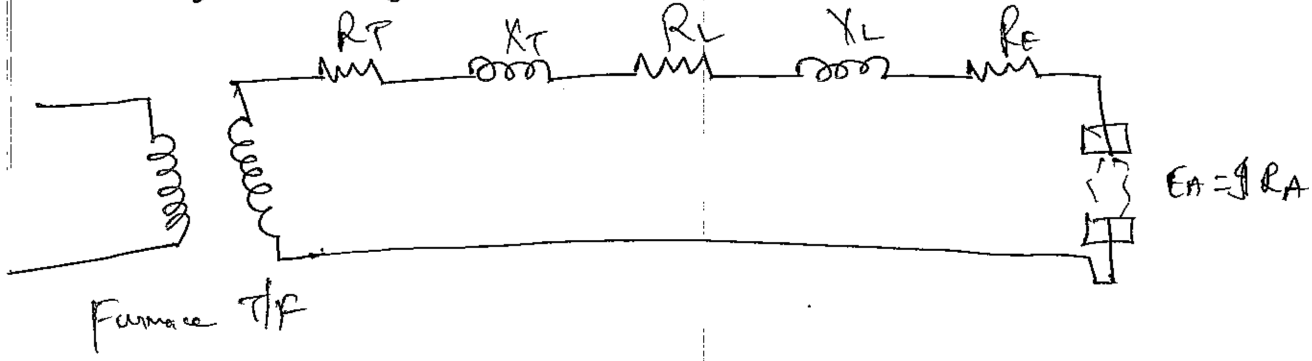
In case of indirect Arc furnace arc is formed between the two electrodes and the heat thus produced is passed on to the charge by radiation.

In case of Direct Arc furnace bottom of the furnace forms part of the electric circuit so that current passes through the body of the charge which offers very low resistance hence it is possible to obtain high temp in such furnaces. It produces uniform heating.

In case of indirect arc furnace arc is struck by short ckt the electrodes for a moment & then withdrawing apart. The heat from the arc & the hot refractory lining is transferred to the top layer by radiation. The heat from the top layer of the charge is further transferred to other parts of the charge by conduction.

Q2. A Explain purpose of using reactor in electric Arc furnace. Deduce the P.F at which heat generated will be maximum.

Eq ckt of Arc furnace



Reactors are installed in the feeder system of an electric arc furnace on the primary side of the furnace T/F in order to improve the efficiency of the furnace especially during the melting process. By increasing the source impedance of the (EAF) power supply, the arc will be stabilised, the consumption of the graphite electrode & tap to tap time will be reduced.

Condition for Max O/P

Arc current $I = \dfrac{V}{\sqrt{(R_T + R_L + R_A)^2 + (X_T + X_L)^2}}$

Power loss $= I^2 R_A$

$$= \frac{V^2}{(R_T + R_L + R_A)^2 + (X_T + X_L)^2} \times R_A$$

$$= \frac{V^2 R_A}{R_A^2 + 2R_A(R_T+R_L) + (R_T+R_L)^2 + (X_T+X_L)^2}$$

$$= \frac{V^2}{R_A + 2(R_T+R_L) + \frac{(R_T+R_L)^2}{R_A} + \frac{(X_T+X_L)^2}{R_A}}$$

Power will be max when Denominator = 0

$$\therefore \frac{d}{dR_A}\left[R_A + 2(R_T+R_L) + \frac{(R_T+R_L)^2 + (X_T+X_L)^2}{R_A}\right] = 0$$

$$\text{or } R_A = \sqrt{(R_T+R_L)^2 + (X_T+X_L)^2} \quad \text{—— (1)}$$

Power factor at max power loss.

$$\cos\phi = \frac{R_A + R_T + R_A}{\sqrt{(R_A+R_T+R_L)^2 + (X_T+X_L)^2}}$$

$$\cos\phi = \frac{R_A + R_T + R_L}{\sqrt{2R_A^2 + 2R_A(R_T+R_L)}} \quad \{\text{using eq (1)}\}$$

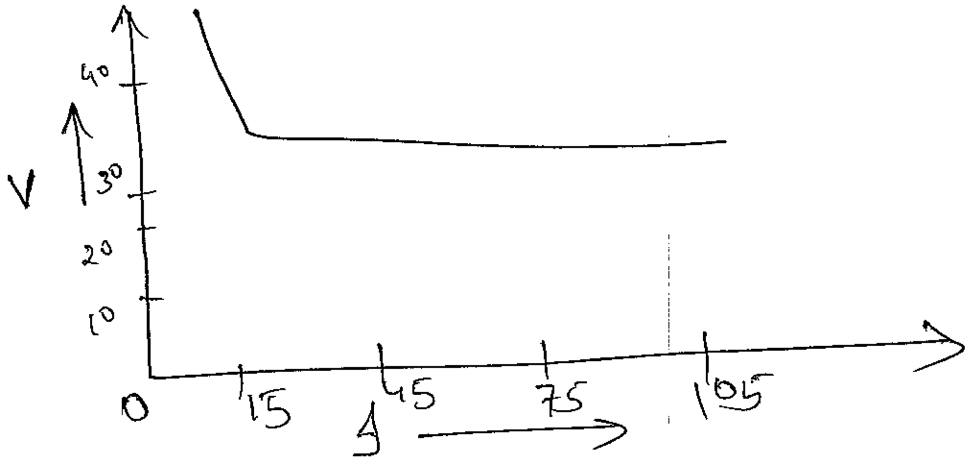
$$= \frac{1}{\sqrt{2}}\sqrt{1 + \frac{R_T+R_L}{R_A}} = \frac{1}{\sqrt{2}} = 0.707$$

$$\therefore \cos\phi = 0.707$$

2. (B) Give detail explanation of electrical property of Arc.

(i) Arc Stability :- It has -ve resistance characteristics.

$$I = \frac{V}{R} \text{ or } R = \frac{V}{I} \text{ ohm.}$$



VI characteristic of an electric Arc.

(ii) Arc blow :- The space around arc and in the adjacent metal is always effected by mag. fields which tend to deflect the arc. This arc blow.

(iii) Sufficient Voltage is required to strike an arc than to maintain it.

Unit IV

Q3(A) What are polar curves? Rousseau Diagram and its importance in illuminating engineering?

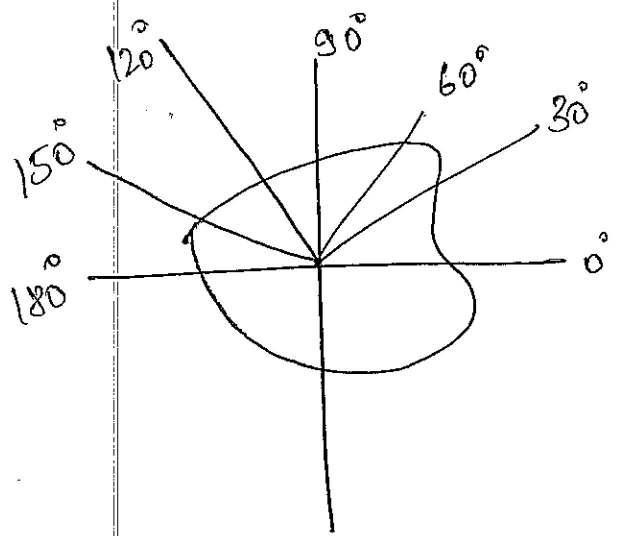
Sol: luminous flux emitted by a source can be determined using the intensity distribution curves. Till now we assumed that the luminous intensity or candle power from a source is distributed uniformly over the surrounding surfaces. The luminous intensity or the distribution of light can be represent with the help of polar curve.

Polar curve are used to determine the actual illumination of the surface by employing the candle power in that particular direction as read from the vertical polar curve. These are also used to determine mean horizontal candle power (MHCP) and mean spherical candle power. (MSCP).

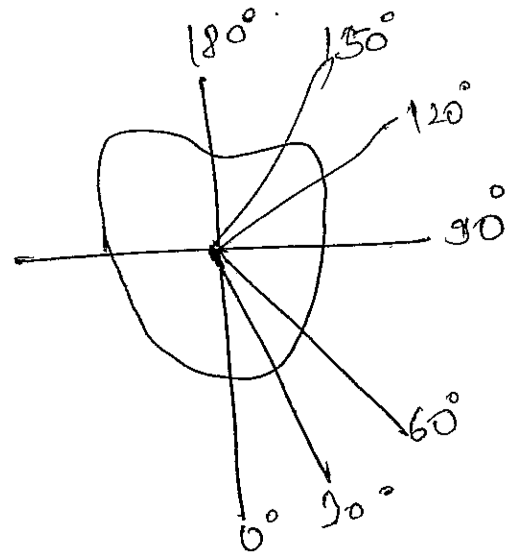
Rousseau Diagram

It is used to find the mean spherical candle power of a symmetrical source of a light from polar curve.

- The curve ABCDEFA so obtained by joining the ordinate is known as Rousseau's curve.



(a) Horizontal Polar Curve



(b) Vertical Polar Curve

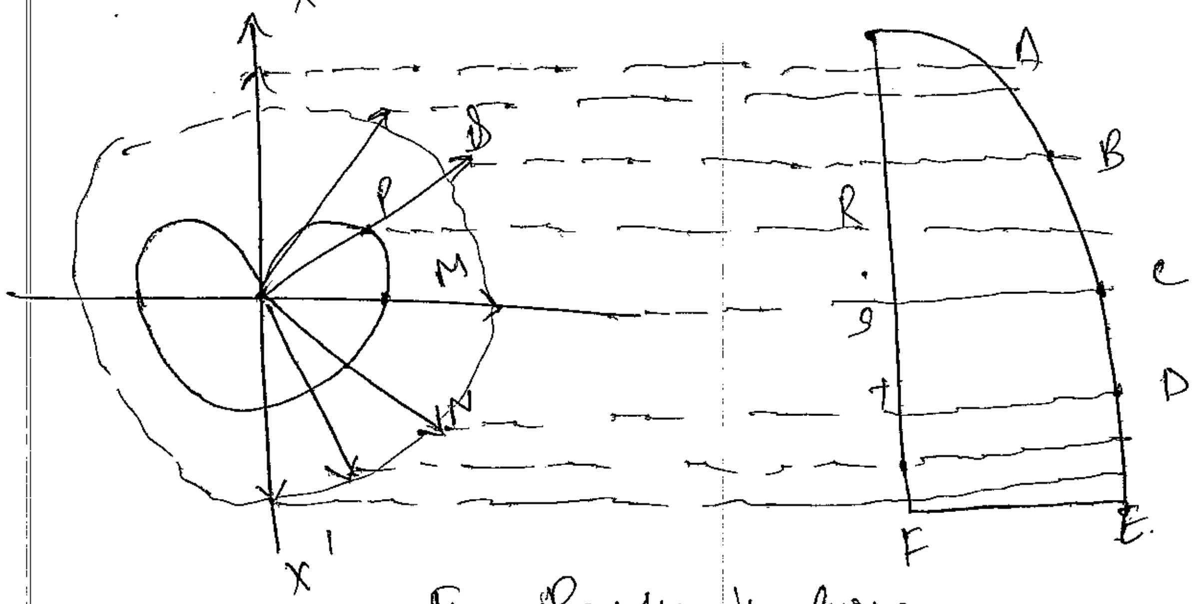


Fig Rousseau's Curve.

3(B) What is Photometry? Describe photovoltaic method of photometry & discuss its limitation.

Photometry is the measurement of lights brightness or luminous intensity, Photometry frequently focuses on the perceived brightness to the human eye. As such it takes into account the eye's sensitivity to varying degrees of light and focuses primarily on the visible light spectrum.

Photovoltaic Method:-

Photovoltaic cell consists of a base metal plate and it is made up of either steel or Al over which a metallic selenium layer is situated which is light sensitive.

When light falls on the surface of selenium layer through cadmium oxide layer, selenium compound releases the electron that are sufficient to maintain the flow of current through the external ckt connected betn +ve & -ve electrode.

Drawback:-

Main Drawback of PV cell is if incident light on the surface of cell at ∠60°, the varnish tends to reflect a significant amount of light, So the reflected light does not reach selenium layer. Thus reading is less what it should be according to the cosine law of illumination.

4(A) Discuss the construction and principle of operation and application of high pressure mercury Vapour lamp.

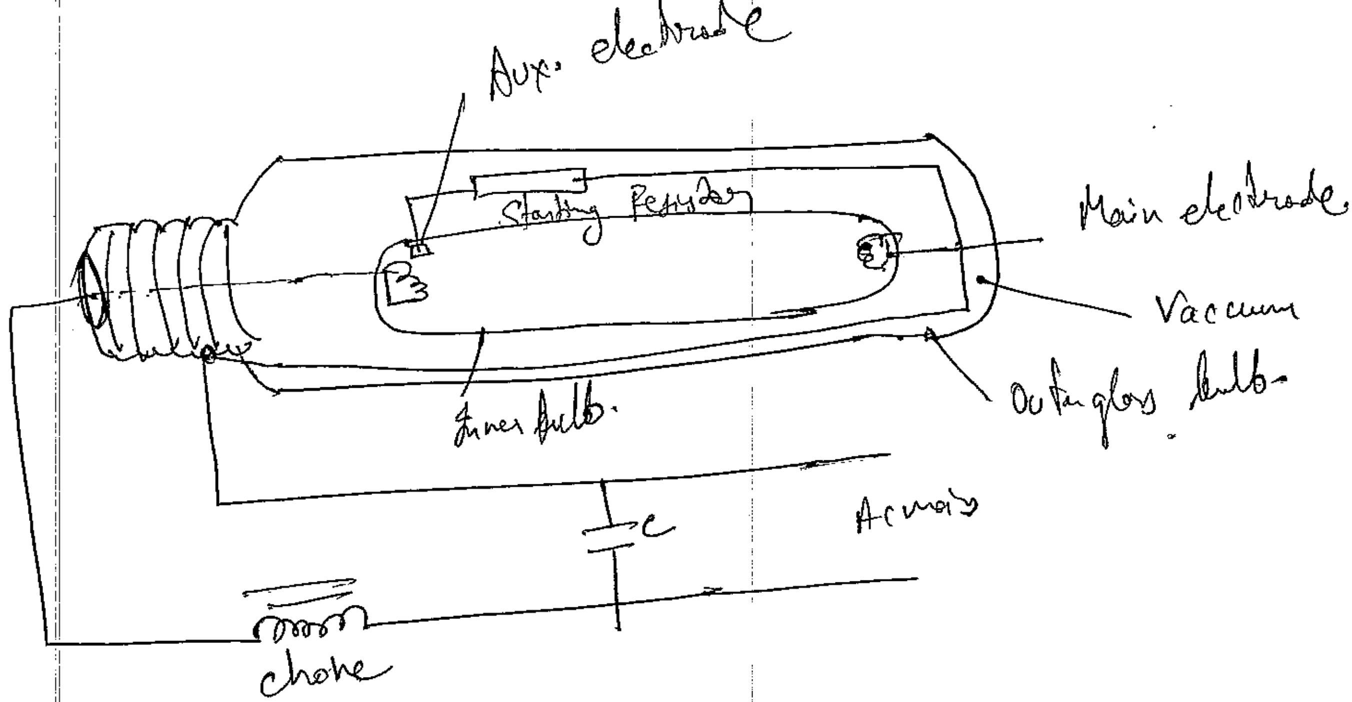


Fig:- Mercury Vapour Lamp.

The tube containing Mercurry vapour is made of hard glass. The inner tube consists of a percentage of argon gas. There are two main electrodes made of tungsten wire and a starting electrode which is spaced quite close to one end of the main electrodes. The phase comes to the first main electrode through the insulated part of the metallic cap.

Operation:- A tungsten filament gets full supply voltage through a thermal switch. It starts emitting it's own light and simultaneously heating the inner mercury bulb. A stage comes when Hg Vapour ionizes with a suitable supply voltage appearing across the main electrode of the inner mercury tube. The bulb are rated 300/500 watts at supply voltage from 200 - 300 volts.

Application:-

(i) Street lighting
(ii) Laboratory Applications
(iii) Medical use in Hospitals.
(iv) Commercial Lightning etc.

Q 4B. Write short Notes on flood lightning & calculations.

The flooding of large surfaces with light and powerful projector is called flood lightning. It may be employed for following purpose.

(i) Enhance the beauty of ancient monument.
(ii) Illuminate advertisement board
(iii) To Illuminate railway yards etc. sports stadium, car parks.

Following steps are reqd in flood lightning calculations:

(i) Illumination level required

(ii) Type of projector

(iii) Number of projectors.

$$N = \frac{A \times E \times \text{Depreciation factor} \times \text{Waste light factor}}{\text{Utilisation factor} \times \text{wattage of lamp} \times \text{luminous efficiency of lamp}}$$

According to the beam spread the projectors may be classified as

(i) Narrow beam projector.

(ii) Medium ∠ projector.

(iii) Wide angle projectors.

B.TECH. VIII th SEM. I MID TERM EXAMINATION (1)

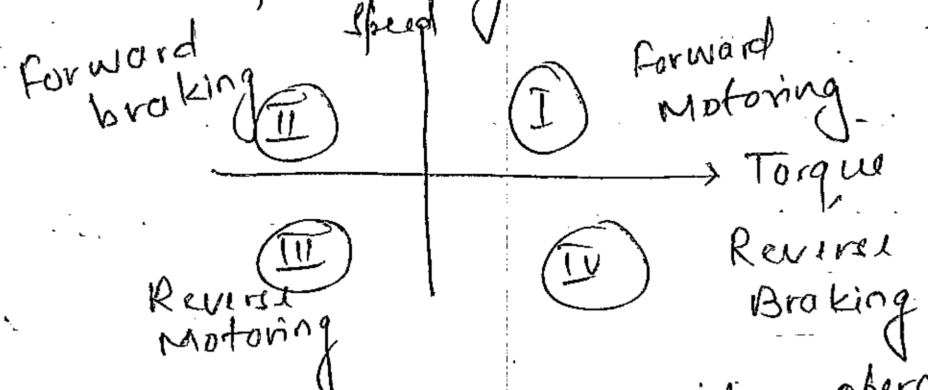
BRANCH - ELECTRICAL ENGINEERING

SUB: ELECTRIC DRIVE AND THEIR CONTROL

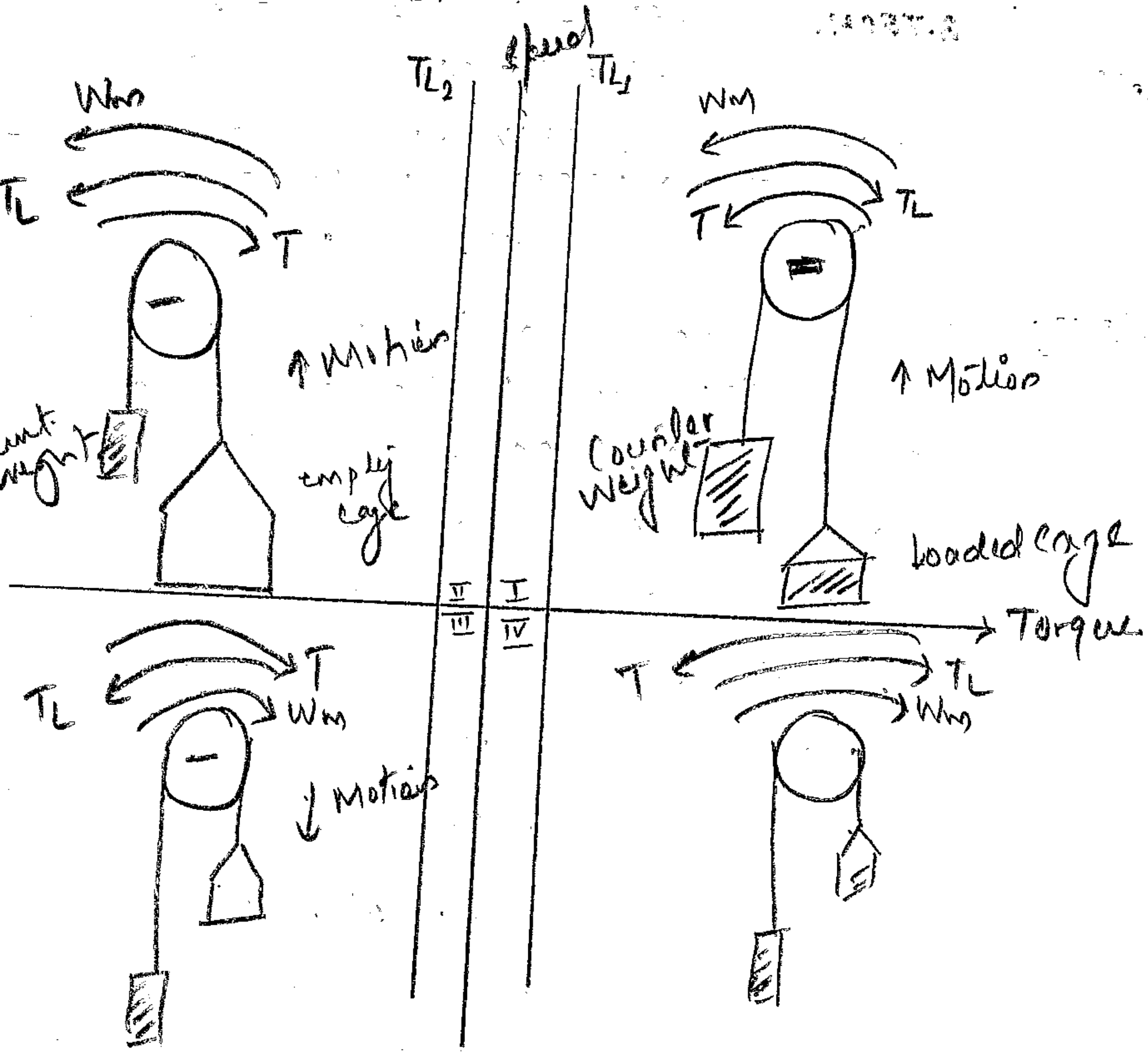
I MID TERM EXAM SOLUTION

UNIT- ONE.

Q.1(A) Soln :- Multiquadrant operation of drives is useful to establish suitable conventions about the signs of torque and speed. Plot of speed-torque characteristics of the load/motor for all four quadrant of operation is known as quandrant diagram. A motor operates in two modes — motoring and braking. Power developed by motor is given by the product of speed and torque. For motoring operation power developed is positive and for braking operation power developed is negative.



* For better understanding, let us consider operation of Hoist in four Quadrants. A Hoist consist of a rope drum wound on a drum coupled to the motor shaft. One end is tied to a cage which is used to transport man or mat. and another end has counter weight.



Quadrant I: Hoist moves in upward direction, which corresponds to the positive motor speed which is in counter clockwise direction here

Quadrant II :- When a loaded cage is lowered, since the wt. of the loaded cage is higher than that of counter weight. It is able to overcome [illegible] due to gravity itself.

Quadrant III :- is obtained when an empty cage is moved up. since a counter weight is heavier.

Quadrant IV- Quadrant IV is obtained when an empty cage is

Q1(B) Soln :-

Let a motor driving two loads, one coupled directly to the shaft and other through a transmission system converting rotational motion to linear motion :

$$\frac{1}{2} J W_m^2 = \frac{1}{2} J_0 W_m^2 + \frac{1}{2} M_1 V_1^2$$

$$J = J_0 + M_1 \left(\frac{V_1}{W_m}\right)^2$$

$$T_L W_m = T_{L0} W_m + \frac{F_1 V_1}{\eta_1}$$

$$T_L = T_{L0} + \frac{F_1}{\eta_1}\left(\frac{V_1}{W_m}\right)$$

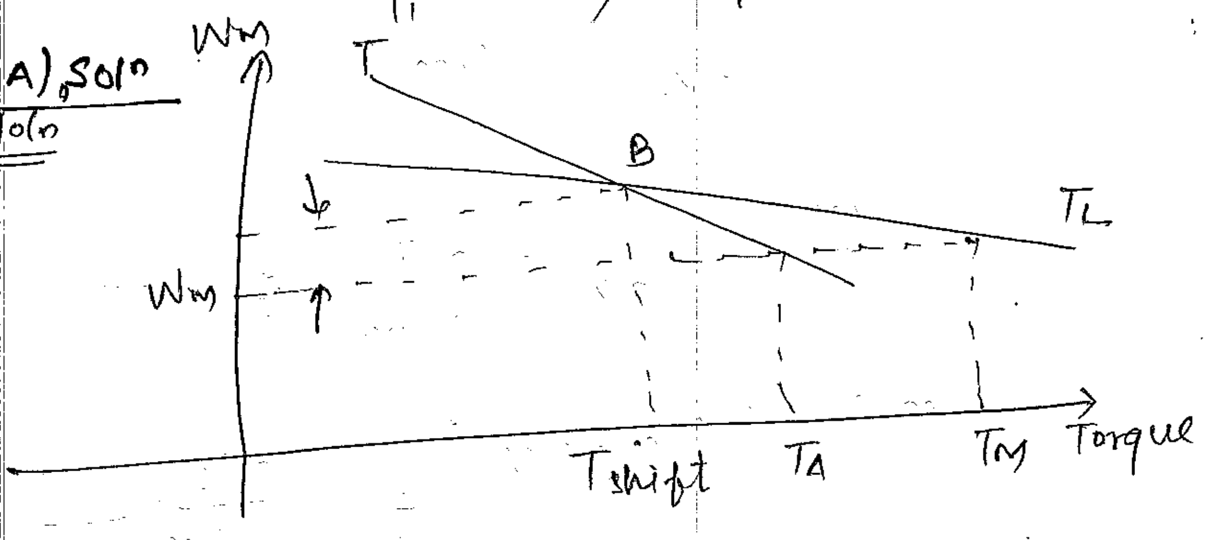
$$J = J_0 + M_1\left(\frac{V_1}{W_m}\right)^2 + M_2\left(\frac{V_2}{W_m}\right)^2 + \cdots$$

$$T_L = T_{L0} + \frac{F_1}{\eta_1}\left(\frac{V_1}{W_m}\right) + \frac{F_2}{\eta_2}\left(\frac{V_2}{W_m}\right) + \cdots$$

OR.

Q2(A) Soln

Q.2(A) Soln



From the above discussions, an equilibrium point will be stable when an increase in speed causes load torque to exceed the motor torque. i.e. when at equilibrium point following conditions is satisfied.

$$\frac{dT_L}{dW_m} > \frac{dT}{dW_m}$$

$$(T+\Delta T) = (T_L + \Delta T_L) + J\frac{d(W_m + \Delta W_m)}{dt}$$

$$= T + \Delta T = T_L + \Delta T_L + J\frac{dW_m}{dt} + J\frac{d\Delta W_m}{dt} \quad -(1)$$

Gen equ:

$$T = T_L + J\frac{dW_m}{dt} \quad -(2)$$

Equ (2) − (1)

$$J\frac{dW_m}{dt} = \Delta T - \Delta T_L$$

$$\Delta T = \left(\frac{dT}{dW_m}\right)\Delta W_m$$

$$\Delta T_L = \left(\frac{dT_L}{dW_m}\right)\Delta W_m$$

$$J\frac{d\Delta W_m}{dt} + \left(\frac{dT_L}{dW_m} - \frac{dT}{dW_m}\right)\Delta W_m = 0$$

$$\Delta W_m = (\Delta W_m)_0 \exp\left\{-\frac{1}{J}\left(\frac{dT_L}{dW_m} - \frac{dT}{dW_m}\right)t\right\}$$

Q. 2. Soln :- (B).

Electric drive :- electric drive is defined as a form of m/c equipment designed to convert electrical energy into mechanical energy & provide electrical control of this process.

Advantages & disadvantages

Advantages :-

1. electric drives are availaible over a wide range of power from few ~~months~~ watt to Mega Watt.
2. Pollution free.
3. Cost is too low.
4. operate in all four Qudrants.
5. they are availaible in wide range of power, torque & speed.

Disadvantages :-

1. it is tied only upto the electrified Area.
2. Failure in supply for a few minute may peralayze the whole system.
3. Fatal Accidents.

Q. 3(B). Soln :-

UNIT 2.
DC DRIVES

Starting :-

The most important process associated with the controlled electrical drive are :-

(i). starting
(ii). speed control
(iii). braking
(iv). Reversing the direction of rotation.

starting of an electrical drive involves a change in its state from rest to a steady state speed of rotation.
The process of starting is the most important phenomenon in the entire operation of the drive. Control of the starting process essentialy consist of controlling the acceleration of the driving motor.

Effect of starting on power supply, Motor and Load :-

While studying starting of electric drive systems, it is necessary to consider three factors:

i). effect of starting upon the power supply.
(ii). effect of starting upon the driving motor itself

(iii). effect of starting upon the connected mechanical load.

The supply N/w to which motor is connected may affect the selection of starting device from the following view point. The excessive voltage drop due to the peak starting current may interfere with the supply in such a way that it cannot be tolerated by other equipment or other consumers connected to the same power supply network.

Since starting is associated with excessive currents, the effect of starting upon the motor itself must be carefully considered.

Method of starting electric Motors

There are various methods like :-

1) Full Voltage starting :-

This involves the application of full line voltage to the motor terminals. This is also called 'direct on line ~~voltage~~ starting'. DC motors upto 2KW & squirrel cage induction motors as well as certain synchronous motors upto 4 or 5KW are usually line started.

2). Reduced voltage starting :-

In order to reduce heavy starting current & the consequent voltage dip in the supply lines majority of motors are started by applying a reduced voltage to their terminals & subsequently increasing it to its normal value.

3) Increased Torque starting :-

With a wound rotor induction motor, resistance can be added in the rotor ckt so as to decrease the starting current while increasing the starting torque, even, upto value of maximum torque that can be developed by motor.

4). Starting by means of smooth variation of voltage or frequency :-

With a c motor - dc generator sets, dc motors can be started by smooth variation of applied voltage and with variable frequency sources both induction and synchronous motors can be started by smooth variation of supply freq, simultaneously varying proportionally the applied voltage to the motors.

* Speed of a D.C Motor :-

$$E_b = V - I_a R_a$$

$$E_b = \frac{\phi Z N}{60}\left(\frac{P}{A}\right) = V - I_a R_a$$

$$\therefore N = \frac{V - I_a R_a}{\phi} \times \left(\frac{60A}{ZP}\right) \text{ r.p.m}$$

$$V - I_a R_a = E_b$$

$$\therefore N = \frac{E_b}{\phi} \times \left(\frac{60A}{ZP}\right) \text{ r.p.m}$$

$$N = K \frac{E_b}{\phi}$$

$$\therefore \boxed{N \propto \frac{E_b}{\phi}}$$

* Torque & speed of a D.C Motor

$$N = K \frac{V - I_a R_a}{\phi} = K \frac{E_b}{\phi}$$

$$\boxed{T_a \propto \phi I_a}$$

* Factors Controlling Motor Speed :-

$$N = \frac{V - I_a R_a}{Z\phi} \cdot \left(\frac{A}{P}\right)$$

$$N = K \frac{V - I_a R_a}{\phi} \text{ rps.}$$

* Speed can be controlled by varying

(i) Flux/Pole (Flux Control Method)

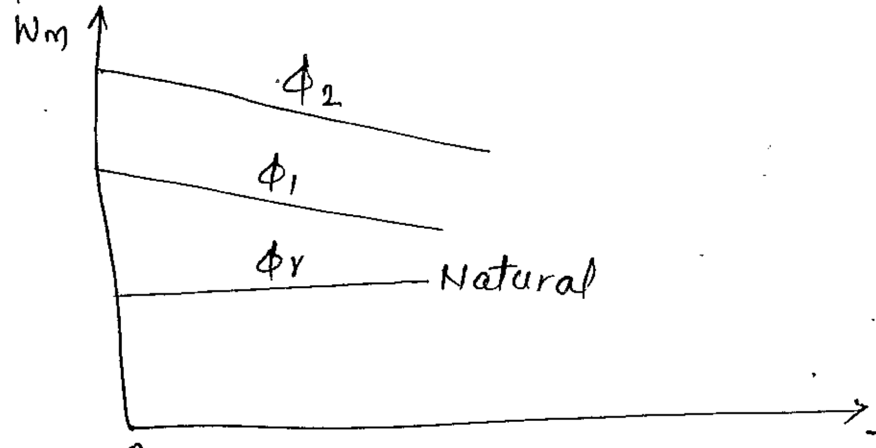
(ii). Resistance R_a of armature ckt (Rheostatic Control).

(iii). applied voltage V (Voltage Control).

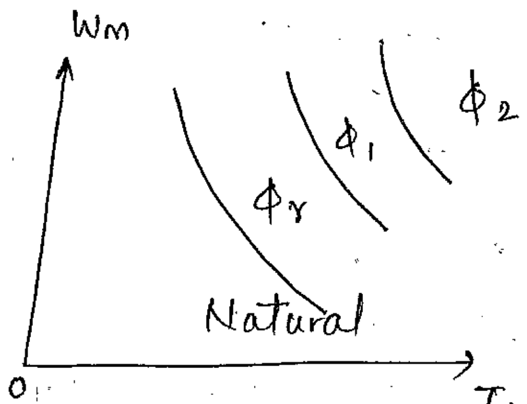
Speed Control of Shunt Motors :-

It is seen from above that $N \alpha \frac{1}{\phi}$. By decreasing the flux, the speed can be increased and vice versa Hence, the name flux or field control method. The flux of a dc motor can be changed by changing I_{sh} Is relatively small, shunt field rheostat has to carry only a small current, which means I^2R loss is small, so that rheostat is small in size This method is very efficient. In non-interpolar m/c, the speed can be increased by this method in the ratio 2:1.

* Torque speed curves:-



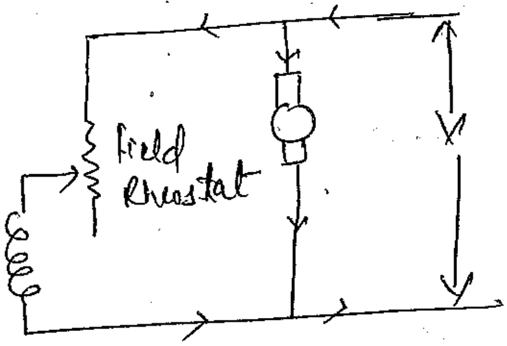
(a). Seperately excited D.C. Motor

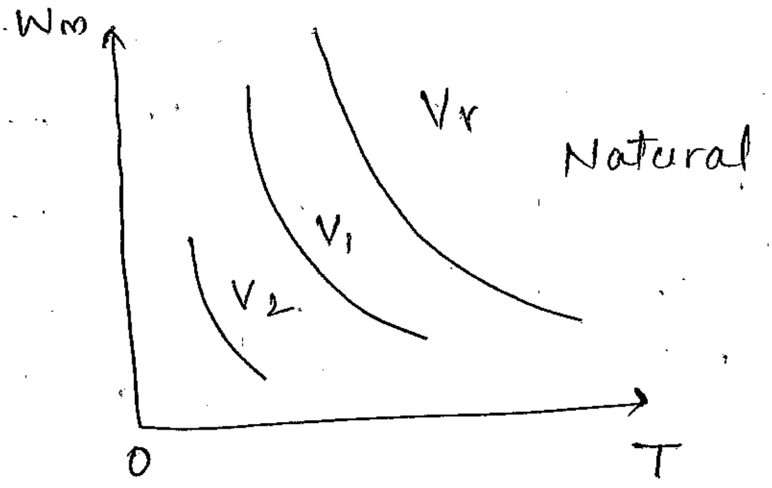


(b). series

$\phi_r > \phi_1 > \phi_2$

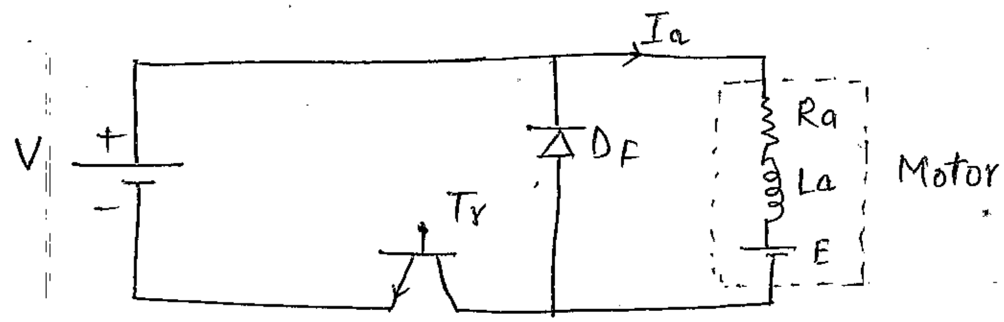
*. Ckt diagram:-

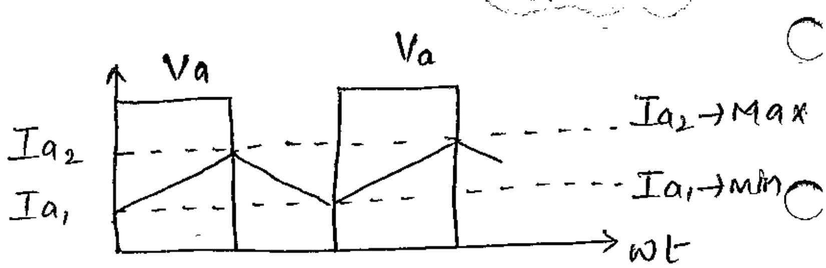




Q.4(B) Soln :-

* Chopper fed DC Motor Drives :-





* Motoring Control

Mode I: During on-period of the transistor, $0 \leq t \leq t_{on}$, the motor terminal is V. The operations is described by

$$R_a I_a + L_a \frac{dI_a}{dt} + E = V,$$

$$0 \leq t \leq t_{on}$$

In this interval, armature current increases from I_{a1} to I_{a2}. Since, motor is connected to the source during this interval, it is called duty interval.

Model 2 At $t = T_{ON}$, Tr is turned-off. Motor current freewheels through diode D_F and motor terminal voltage is zero during interval $t_{on} \leq t \leq T$. Motor operation during this interval is known as freewheeling interval. and is described by

$$R_a I_a + L_a \frac{dI_a}{dt} + E = 0, \quad t_{on} \leq t \leq T$$

→ Motor current decreases from I_{a2} to I_{a1} during this interval.

δ → duty Ratio/cycle

$$\delta = \frac{T_{ON}}{T} \quad \text{— (1)}$$

$$V_a = \frac{1}{T} \int_0^{T_{on}} V\,dt = \delta V \quad \text{— (2)}$$

$$I_a = \frac{\delta V - E}{R_a} \quad \text{— (3)}$$

$T = K I_a$, $E = K W_m$

Put in equ (3).

$$W_m = \frac{\delta V}{K} - \frac{R_a}{K^2} T$$